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SOVIET RESEARCH ON RADIOACTIVE SUBSTANCES

Several Soviet scientists have studied the radioactive content of living as well as inanimate matter. For example, K. G. Kunasheva has made studies of the radioactive content of plants, animals, and even the muds found in the Barents Sea.(1) In one series of experiments Kunasheva attempted to determine the amount of radioactive materials which could be found in the living organisms of plants as well as animals.

Prior to the experiments, she collected from 5 to 6 kilograms, live weight, of each of the substances to be studied. Plant material was first air dried while animal organisms were dried in a constant-temperature chamber at 100 degrees or were fixed with alcohol or formalin. This dried material was powdered in a porcelain dish and calcined until a raw ash was obtained. The powder was then sifted so as to remove all traces of sand and leave only vegetable or animal matter. Whatever radium was contained in these siftings was studied by the emanation method with the aid of a Shmidt electrometer (sensitivity of these instruments was 5×10^{-12} grams of radium).

The test material was usually in batches of one to 2 kilograms, live weight. A given amount of powder was treated with hydrochloric acid to dehydrate the SiO_2, and then filtered. On evaporation, the mixture was cooled and air dried, then heated under glass until the oxides were dissolved. The mass was then mixed with boiling water and filtered. In this operation most of the ash goes into solution. The residue after the final filtration was further calcined and fused in an iron crucible with an alkali mixture, equal to 7 times the amount of powder. This alkali mixture was composed of 2 Na_2CO_3 + 5 KOH + 0.1 grams $BaCl_2$. The powder and alkali mixture was heated, fused, and then cooled. The residue was easily dissolved in boiling water, and the solution was then filtered. The filtrate was washed with a hot solution of one percent Na_2CO_3 until there was no reaction to SO_4'', then treated with HCl. The solution was once again heated to boiling.

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Radium together with Ba precipitates upon the addition of H_2SO_4. This permitted a quantitative precipitation of the radium contained in the plant or animal matter. The combined sulfates were fused with sodium carbonate. The cooled melt was extracted with hot water, filtered, and washed with one percent Na_2CO_3 until disappearance of the sulfate ion reaction. After treatment with HCl to remove carbonic salts, the solution was placed in a 60-80 milliliter capacity diffuser, the ends were soldered, and emanations were permitted to accumulate in the closed vessel. The period of accumulation was from 7 days to one month.

The vacuum method was used to transfer the emanations into the ionization chambers. Actual measurements were made by comparing activity of the test material with the activity of a known amount of radium by means of an electroscope.

Two standards were used to measure the amount of radium in the test materials. One standard supplied by the Physikalisch-Technische Reichsanstalt, Charlottenburg, contained 3.33×10^{-9} grams of radium, and the other one, developed by the Radium Institute of the Academy of Sciences USSR, contained 4.32×10^{-10} grams of radium. Two to three tests were made of each batch to double check the results. Some of the tests were conducted on two samples of Dicotyledones which were obtained from the Petergof Natural Science Institute at Leningrad. The two plants were of different families. However, they appeared to present the same picture with respect to radium content.

Other tests were conducted on aquatic plants (Cerathophyllum demersum from the Klyaz'ma River), and it was found that the amount of radium which was contained in the plants themselves was about 100 times that which was contained in the water from which the plants were taken (water contained 3.2×10^{-14} percent radium). Other samples of plants were obtained in 1936 from the forest preserve of the Academy of Sciences Ukrainian SSSR, located at Kiev. The amount of radium found in dicotyledonous plants was more than that which was found in monocotyledonous plants. Two examples of plants at the Kiev forest preserve (the water contained 10^{-14} percent radium) were obtained from the same water reservoir. One, the Stratiotes aloides, contained 0.3×10^{-12}, while the Helodes canadensis contained 3.7×10^{-12} percent.

It was further decided to establish whether or not the radium content differed at various stages of the development of plants. Particular attention was paid to two types of wheat, the Prelude and the Ferrugineae, grown at the Petergof Natural Science Institute. It was discovered that the lowest amount of radium was found in the seeds, and as the plants grew, the amount of radium also increased, with the result that at the end of the development of the plants, they contained their greatest amount of radium. The same sort of phenomenon was noticed in the case of Pisum sativum which was grown on a synthetic nutrient media to which radium salts had been added.

In the experiments, plants were obtained from all parts of the USSR. It was found that the Boletus edulis, obtained from Staroselo, Kiev, in 1936, contained the least amount of radium, about 2.2×10^{-13} percent of the live weight. The Rhodymenia palmata, representative of those plants obtained from the Kola Gulf, Barents Sea in 1938, contained about 2.2×10^{-13} percent radium to the live weight of the plant. However, in all cases it must be noted that the amount of radium found in the plants themselves was more than that found in the sea water from which the plants were obtained. A comparison of radium content in animals and plants showed that the amount of radium in animals was definitely lower. Only in one case, that of the Balanus belanoides (Kola Gulf, 1938) was the amount of radium equal to 1.16×10^{-12} percent of live weight. This was one of the few cases where there was an accumulation of radium by a living organism other than a plant.

Many scientists, both Soviet and foreign, have conducted research to determine the amount of radium generally found in the soil. It is notable that the amount of radium found in the soil very closely corresponded with the amount of radium found in plants. Thus, there are cases where increased amounts of radium in the soil were reflected by similarly increased amounts of radium in the plant.(2)

As a result of these studies(1), it was possible to make several conclusions. In the first place, every plant and animal which was studied contained some amount of radium. Generally, it can be stated that the amount of radium for fresh water, land growing, and marine plants was in the vicinity of 10^{-12} percent of live weight of the plant. The amounts naturally differed with specie and type of development.

Moreover, Kunasheva suggested that it might be wise to conduct experiments to determine the relationship between the amount of radium in the plant and the genus of the plant or the nature of the environment in which it develops. One of the facts discovered was that marine animals generally contained less radium than marine plants (about one power less). However, this was still one power more than the amount of radium which is found in the sea water from which these plants or animals were taken. Tests with wheat showed that the amount of radium gradually accumulates as the plant develops. On the basis of 100 tests, it was determined that in plants the amount of radium was generally $n \times 10^{-12}$ percent, while for marine animals it was $n \times 10^{-13}$ percent of the live weight.

Kunasheva has also studied the amount of radium or thorium that was found in the muds which she obtained from the Barents Sea.(3) The data presented in that study were among the first to be published in this field and were the first indications of some of the work being done in the Biogeochemical Laboratory, i.e., determination of radioactive element content in various muds, and in particular, muds obtained from the depths of the oceans. (A. P. Vinogradov, conducting studies in the same field has published an article entitled "Distribution of Chemical Elements in the Sea Waters."(4))

In her research, Kunasheva studied about 15 samples of muds which were obtained by N. V. Klenov and were more or less characteristic of the various types of mud bottoms found at stated distances off shore. The mechanical and chemical properties of these muds were studied at VNIRO, and the results were published in Trudy Vsescyuznogo nauchnoisledovatel'skogo instituta Morskogo Rybnogo Khozyaystva i Okeanografii.

The emanation method, mentioned previously, was used to study the amount of radium in these muds. Generally, the material to be studied was first dried in a constant-temperature chamber at 105 degrees until a standard weight was reached. This weight was important since all further calculations were based on this standard. The dried muds were then calcined in a porcelain dish, and an alkali mixture, similar to tests on plants and animals, was then added. The mixture was extracted with warm water and filtered. On washing with soda, the residue was dissolved in 5 percent HCl whereupon radium isotopes together with barium were precipitated. Once again, a Schmidt electrometer was used, along with the standard established by the Radium Institute, Academy of Sciences USSR.

Mud samples were obtained from Motovskiy Zaliv, the Barents Sea, and some samples were obtained from Norway and the Norway Sea. These latter appeared to have the highest radium and thorium content. In general, the amount of radium in the various muds which were studied was between 4×10^{-11} and 9.9×10^{-11}. This generally agrees with data obtained by other scientists who studied the radium content of marine terrigenous muds and sedimentary rock. The amount of thorium in these muds was between 4.8×10^{-4} to 8.8×10^{-4}.

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Tabulated test data showed that at station No 2813, located at 71 2 N, 8 48 5 E, at the over-all maximum depth of 443 meters, where there was a sandy grey bottom, the amount of radium was 9.9 x 10^{-11} percent and the amount of thorium was 8.1 x 10^{-4} percent. The shallowest depth was 42 meters at Yekaterininskoye Bay where the amount of radium was 4.5 x 10^{-11} percent and the thorium content was 4.8 x 10^{-4} percent.

In 1941, studies were made to determine the amount of radioactive elements in soils of the Crimean Peninsula.(5) The samples were obtained by vertical sampling. The ultimate aim of these studies was to make a complete study of USSR soils to determine the conditions surrounding migration of radioactive elements in connection with soil formation. For the purpose of these experiments, several samples of Crimean soils were obtained and thoroughly studied by I. N. Antipov-Karatayev. Each of the soil samples to be studied was calcined to remove organic matter and fused with KOH and $BaCl_2$. The melt was then extracted with hot water and the insoluble residue was washed with a 10-percent solution of soda to assure better separation of the silicic acid and then dissolved in HCl (1 to 1). The radium isotopes were precipitated in the usual manner.

The solution which contained radium isotopes was then concentrated until a given amount was obtained and placed in a special chamber where emanations of radium and thorium-x were studied. A Lutz-Edelman filament electrometer was used to make the measurements of radioactive emanations. It was generally found that the amount of radium and thorium in the soil compared favorably with the amount which was found in the rocks underneath the soils. It was noted that the amount of radium was usually highest in the upper horizons of the soil. The richest radium and thorium content, relative to the underlying rock, was found in the soil over limestone. The sample was taken from cut No 36 (Nikitskiy Garden) and was found to contain many times more thorium than radium. This finding led to the idea that in determining the amount of radioactive substances in soils, it is necessary to relate the chemical composition of the soil which is being studied to that of the underlying rock formation.

It was supposed that radium accompanies calcium, and thorium accompanies F_2O_3. It is true that the Th/RaO_3 relationship is more stable than the absolute content in soil while the Ra/CaO relationship is less stable. Thus, in disintegrated limestone calcium is lost and only radium remains. Therefore, it may be assumed that radium and thorium are related to the accessory minerals of limestone which are converted into terra rossa, whereas soils on top of diorite do not differ from the underlying rocks either in chemical composition or radium and thorium content.

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